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ANTICIPATORY REACTION[1]

By Professor RAYMOND DODGE

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ONCE in a while in the classical reaction experiment there occurred a disturbing phenomenon. Instead of trailing along in orthodox sequence the reaction occasionally came before the regular stimulus. What could one do with such a tactless event? As an experimental datum it couldn't be arbitrarily ignored. Yet it just wouldn't fit in with the other data. Like some other relegates to the scrap heap of science it might have suggested a reinterpretation of the stimulus-reaction schema, or at least some correction of its interpretation. Some of us at Yale believe that it does. "Oh, I see," you say, "the conditioned reflex is in the woodpile." But it isn't exactly that. If I may state the conclusions at the beginning I believe that there is abundant evidence that the doctrine of direct bonds between a specific stimulus and a specific reaction, instead of being the general plan of all behavior, is either an artifact due to imperfect description or a special limiting case of laboratory experiment. In every-day human life, as well as in the laboratory, most specific reactions are selected phases of a complex flux of organic response evoked by a complex flux of stimulation and inhibition, some part of which is arbitrarily called the stimulus. This dual flux reaches into a more or less remote past and a more or less remote future. It shows a highly complicated system of present meanings in individual experience and appears as extensive ramifications or spread and systematization of impulses within neural tissue. In this flux the recurrence of identical set-stimulus-reaction sequences is highly improbable. The usual sequences are between more or less variable systems. They may be called for convenience the stimulus system and the reaction system, but in reality the relation is quite intimate.

In systems of irritable tissue the action of each part of the system often appears in a dual rôle. Central

[1] Presidential address delivered before the New York Branch of the American Psychological Association at New Haven, April 1, 1933.

tissue, at least, reacts to stimulation by some of its physiological neighbors, and it stimulates some to reaction. The same neural events in irritable tissue may be both a reaction and a stimulus. Both are really related or identical phases of organic systematization, expressions of the organism's capacity to react in a systematized way. The concept emphasizes two main points. Every so-called specific reaction is an arbitrary phase of a complex reactive adjustment flux. Every so-called specific stimulus of a tissue is an arbitrary phase of a complex flux of environmental changes without definite beginning and without definite end. The two may be, and often are, different functions of the same neural event, due to its different systematic relations within the organism.

The relationship is even closer. The flux of stimuli from the environment of the organism through the sense organs, through the nerve trunks and ganglia to the musculature and glands is paralleled by the flux of reactions. Changes in the environment are stimuli only when they evoke organic reaction. Reaction occurs only in response to stimuli. Each implies the other throughout. There is no neural stimulus without a corresponding neural reaction, no neural reaction without changes in the vital environment of the tissue that reacts.

In view of this fundamental biological relationship between stimulus and reaction a real anticipatory reaction is an impossible absurdity. It simply can not exist, yet somehow the impossible is actual.

It would be an unfortunate misunderstanding of the term "anticipatory reaction" to limit it to the occasional miscarriage of the traditional reaction experiment. Both Hull and I, from different approaches, have pointed out its wide-spread importance in the conduct of vital adjustments. Thurstone rightly held that anticipatory reaction is a real but strangely neglected measurable indication of intelligence. A large part, if not the largest part, of a rational person's life is spent in planning for events that may not occur.

It is generally recognized that there are two forms of reaction to circumstances. One is centrifugal and the other is centripetal. The one modifies the environment to make it livable, and the other modifies the individual to live in a given environment. Either centripetal or centrifugal reactions may be of one or the other of two types. The one type refers to events as they occur, making the best of what comes, whether bank failure, loss of fortune or any other more or less disturbing change in situation. Centrifugally it locks the door after the horse is stolen. Centripetally it exploits or utilizes events in the development of character and personality. It might be called the *nous pathetikos*. But there is another type of mental activity that locks the door lest the horse be stolen. It is related to foresight and creative imagination. It aims to adapt to bad news or any other indication of future circumstances by developing beforehand certain resistances, inhibitions, philosophies of life. Moral education, stoicism and epicureanism represent phases of such adaptation. In it there is a certain creative evolution of the control by each individual, either of himself or of events. This is the *nous poetikos*.

While the two types seldom occur in pure form, the first is particularly apparent in infrahuman reaction. The second is more characteristic of man. It includes vital planning of all sorts, casual and systematic, immediate and remote, planning for the next dinner, planning for social contacts, planning scientific experiments, planning for family continuity or life work. It is involved in all orderly development of conduct. It appears in the predictive value of science.

Vital planning may occur in various frames, such as economic, social or moral. Economic planning involves all sorts of insurance against want and disaster, like automobile, fire, theft and accident insurance, life insurance, annuity. It involves the saving of surplus and its investment. The social frame of anticipatory reaction involves adjustments for the convenience, safety and welfare of society, from defensive arming of a nation to shoveling off snow and ice from one's sidewalk so that we, our neighbors and the casual pedestrian may not fall. Moral planning includes the general organization of life to definite ends according to our system of values and goal ideas. It runs the entire gamut of adjustment of our conduct to the moral susceptibilities and prejudices of individuals and groups, from watchfulness at street-crossings as we drive our automobiles to the ordering of our lives so that we may produce as little damage in the world, as little pain and as much good, as possible.

In all this planful activity the great mass of our reactions are anticipatory. It must be so if they would be useful. Biologically, security and even survival depend upon these anticipations. Failure to foresee accurately and preadjust adequately is not unusual, but it is regrettable and usually regretted. As I see it, one of the main tasks of education, and one of the main functions of science and common sense, is to achieve foresight. The rational conduct of life requires preparation for events before they occur.

The question at issue remains. How can the reaction anticipate the stimulus? Theoretically it can not, but practically it does.

The paradox is not an illusion, and it is far from trivial. On the one hand, it represents a serious discrepancy between the experimental science of mind

and the common-sense conduct of life. On the other hand, it represents a problem of the scientific synthesis of apparently contradictory facts. We conjecture that the answer lies not in the concept of the conditioned reflex but rather in the underlying fact of the spread of neural excitation and its systematization according to differential thresholds.

Under the traditional conceptions of specific reactions to specific stimuli from the environment of the organism the definition of stimulus in common life situations was often impossible and usually difficult. If the reaction flux desired by the traveling salesman is the act of buying goods, signing on the dotted line, paying for the goods, with the hope of recouping outlay by reselling, the sales stimulus flux is commonly more than handing across a well-inked fountain pen. It may include the personal habits of the salesmen as well as his line of patter and the sight of the goods in attractive containers. It may also include inquiry by a customer last week, the total financial situation, a fortuitous favorable bank balance and even an expected inheritance from a dead grandmother. In which case grandmother's death may be a very real factor of the stimulus flux and quite as important as passing over the well-filled fountain pen.

Varieties of Stimuli

In our psychological tradition stimuli external to the organism are commonly classified according to the sensory end-organ which they specifically stimulate. This has a basis not only in convenience but also in sound physiology. Since, as we have seen, there is no organic stimulus without a reacting tissue the two are correlates. But it is equally justifiable to classify the stimulus-reaction process from the standpoint of the particular physical environment which finally evokes the reaction. Both references, however, have their disadvantages. From reference to the environment it has come about in the tradition that electricity, light, sound, contact, chemical action and rotation are commonly uncritically called stimuli and the special sense organs are often called receptors, though we know perfectly well that only certain more or less rapid changes in a limited range of these aspects of the environment act as stimuli and that the neural end-organs are specific reactors of specialized irritability instead of passive receptors. These more sensitive areas are really parts of extensive fields of sensitive reactors of less specific irritability. This is clear enough with respect to electricity, contact and rotation. It is fairly clear with respect to light and sound. The tips of the fingers and the lips are obviously high spots in a gradient of skin sensitivity; canals and cochlea, high spots in a gradient of sensitivity to contact and pressure. The entire body is more or less sensitive to electricity and chemical reactions. Light changes may affect any part of the skin in a relatively undifferentiated way. Sounds may be felt at the finger tips, and various inner parts of the body respond to sound vibrations which are too high to stimulate the cochlea. The terms receptors and receptor fields are still widely current and always misleading. The sensitive neural parts of the so-called receptors are not really receptors at all but primary reactors in the organic reaction flux.

The exact nature of neural stimulation and neural reaction is still largely a matter of conjecture, but enough is known experimentally to make it highly probable that both belong to the electrochemical series of physical events. Irritability of central nervous tissue is not necessarily different from irritability of peripheral tissue just because it lies in an organic environment. Changes in fields of force surrounding central nervous tissue are not necessarily different kinds of stimuli from changes in the fields of force surrounding peripheral neural tissue. The main point is that it can make no essential difference in the reaction of central nervous tissue where its stimuli ultimately derive from. Provided the stimuli evoke similar systems of neural reaction, it is a matter of relative indifference whether they originate in the organism or in its environment. A tissue can react only in accordance with its own reaction capacities to changes in its environment to which it is sensitive at the time.

This point is of great importance to us in the interpretation of anticipatory reactions in those cases which are unfortunately misnamed "conditioned reflexes." There are serious objections to the term, as has been pointed out frequently. To lump all reactions as reflexes doesn't aid description but confuses it. The term "conditioned reactions" would be a little less confusing in view of the widely spread specific connotation of reflex, and Miss Peak's functional discrimination between reflex and voluntary reactions. Moreover, since all reactions have antecedents which adequately condition them, even the term "conditioned" has no special descriptive value. In view of the general use of specific stimuli I could vote with those who would call the "unconditioned reactions" primary reactions and the "conditioned reactions" secondary. *Direct* and *indirect* seem to me still better. In view of the gradually arising belief that the conditioned reaction is never a reaction *de novo* and in view of Pavlov's own analysis it might be best to stick to the more simple descriptive terms reinforced and inhibited secondary reactions.

Types of Anticipatory Reactions

There sometimes seem to be three varieties of reaction which appear to anticipate the natural stimulus.

One emphasizes the systematization in the flux of stimuli, a second emphasizes the systematization of the overt reaction and a third emphasizes the systematization of both stimuli and reaction. However important these differences appear to be in practical life and in psychological thought, they are really more or less illusory. All known systematizations, both experiential and behavioristic, are within the organism. The illusion of extrojection, the projection of inner organic systems into an unknown outside is among the most persistent illusions known to psychology.

In the first mentioned type of anticipatory reaction, emphasizing the systematization of supposedly external stimuli, the reaction may appear to be quite indeterminate, varying from individual to individual, and from time to time in the same individual, not primarily according to the form and framework of the systematized stimuli, but rather according to the repertoire of the reactor. The type is well illustrated by the so-called defense reactions emphasized by Hull, such as the reactions of the dog to the snap of a whip. In some way or other in the experience of that dog, the snapping of a whip comes to be systematically connected with a possible blow. What the reaction shall be depends on the intervening spread of neural excitation, on the habits of the individual and his personality, or his surrogate for personality. Snap and blow may be stably connected in experience, while the reactions may be indeterminate accidents as far as the stimuli are concerned. The dog may cringe, may run away or bark, or his reaction may take any other form that corresponds with his constitutional or momentary set. Similarly in humans the threat of approaching danger regularly means that in some way or another there is a system of events in the experience of the individual which gives a meaning to each threat as it occurs. The threat of disease or financial disability, the threat of personal danger, the threat of assault, are well known in the experience of most of us. Such reactions are not "conditioned" in the sense that there is a specific substitute stimulus for a primitive reaction. The stimuli are systematized into a causal or temporal flux in which the oncoming event gives meaning to each of its predecessors. Overt reactions, like reactions of the dog, depend on the personality of the individual to whom the threat is made, his repertoire and the mood in which he happens to be. If the person threatened by assault is an athlete, an amateur boxer, a weakling or a coward, the reaction probabilities will be characteristically different. But the athlete may feel especially amiable that morning, the boxer cautious, the coward expansive.

Any number of analogous systematizations of experience will occur to my scientific colleagues.

The free association test represents this variety of reaction fairly well in the psychologic tradition. Though the stimulus series is seldom fully organized, response series is still less so. The hope and expectation of the free association test is that it will expose the various dominant systematization tendencies of the individual tested.

A somewhat better illustration is the typical trial and error random response to experimental situations of discomfort, the restless activity in confinement, writhing reactions to pain and the chaotic spread of neural responses in reaction to any strong stimulus whatsoever.

Still better are the preparatory responses to stimuli that have acquired, or are acquiring, meaning. Such are the refixations of the eyes in response to peripheral stimuli. Attractive peripheral stimuli, as in reading, commonly become attractive through some systematic connection or connections with material in the field of attention. One may look to the right in a fairly well-ordered succession of reading eye movements in response to unclear peripheral words, the gradual unfolding of meaning and grammatical construction. As has been shown experimentally every unclear, prefixationally seen word adds something measurably important to the developing apperceptive processes which becomes more important in fixation. Every eye movement under such circumstances is more or less accidental, determined less by the characteristics of the prefixational stimulus than by its relations to the partially systematized flux of inner and outer stimuli. The eye movements in rereading the same text are never twice alike. The meaning may be essentially the same.

A second type of so-called anticipatory reaction emphasizes reaction systems without much reference to the adequacy of the stimulus. Almost any stimulus will revivify the fad of the faddist. Any point in the conversation may serve to remind him of his particular interests, and his reactions are determined by his systems of thought and behavior rather than by any specific bond between stimulus and reaction. The anti-prohibitionist needs no direct or specific stimulus to launch forth on the evils of prohibition; the religionist no specific stimulus to lead him to the contemplation of the all-importance of his relations to God and to related remarks and conduct. Such reactions are personal affairs and expressions of personality. The essentially moral person may be exposed for a long time to degrading situations and preserve his moral reactions. The essentially vulgar finds in every occasion opportunity for an expression of his vulgarity. The habitual offender, in spite of the best reformatory environment, may still remain an offender in his reaction to some social situation. The reformer knows no crushing defeat; beaten to earth he rises

with renewed strength to oppose the evils against which he has devoted his energies. In all these cases, and many more, the reaction might seem to occur apparently spontaneously. Any stimulus may operate to evoke the train of neural events which represent the personality of the reactor. This type presents the probable neural schema of the classical "conditioned reflex" of the salivary glands.

In the flux of systematized behavior most reactions lead somewhere. Each anticipates the oncoming act and prepares for it. As we have elsewhere pointed out, in the stratification of behavior there are no isolated acts, whether reflex, instinctive, automatic or voluntary. There is nothing but a more or less complex behavior flux with varying component factors in varying constellations. Each beginning anticipates an end, each end is also a beginning.

Some of these ends are quite unconscious, some are conscious only as premonitions, while some are fully conscious or are represented by surrogates. The knee-jerk is really complex, however simple it appears. Operating on a basis of psychophysiological set from previous stimuli it may begin with a quick lumbar reflex in a generally useful direction which develops, by the interaction of higher neural systems, toward such complicated adjustive acts as maintaining equilibrium or eliminating obstacles according to the direction of the central elaboration of the sensory data. There is no evidence that the adjustive act is a conscious end of the jerk which begins and in a measure anticipates it.

Preparatory reactions in which there is a premonition of the end are very numerous in every-day life. Every exploration—every sentence we speak or write—every step we take in walking—every corner that we turn in driving, belongs to a reaction system which includes more or less clear premonitions of the future. When we swing out our automobile to take a sharp corner the real stimulus to the swing is in the future. The reaction is an anticipatory reaction. There is evidence that rats which have learned to run a maze do much the same. We often call such future stimuli purposes and the anticipatory behavior purposive even when the purpose is nothing more than a premonition.

Long ago I stumbled across the problem of premonitions in ordinary speech. No one as far as I know has ever given them adequate description. The plain facts are that at the beginning of a sentence one prepares for its conclusion. This was especially obvious for me in the apparently complicated constructions of the German language, but it is more or less true in all languages. The real stimuli to the next word are not given alone in the previous word or sentence but in premonitions of the future, the ending of the current sentence, its place in the argument of the paragraph and the total discourse. Every word is at once a fulfilment of the past and an anticipation of the future.

Similar premonitions occur in the understanding of spoken and written discourse. Many if not all of us have found ourselves ready to supply the unspoken word when the speaker hesitates. Rhyme and rhythm narrow the scope and vivify the premonition. Once upon a time I studied the measurable premonition effects of a prefixational vision in reading. It has been largely neglected in studies of the reading process by overemphasis on fixation points and the span of clear vision. But any one who tries to read the text from spans of clear vision fragments as are explicitly given by Judd and Buswell will realize their inadequacy. The right-sided hemianope for whom these prefixational premonitions are lacking either can not read at all or reads very slowly and imperfectly.

Analogous premonitions probably occur in the appreciation of music and in musical composition. Music in which premonition is an obvious certainty tends to seem trivial. In extreme cases, like the reported composition ecstasy of Mozart, premonition may become unusually condensed and vivid. He reported that on occasion he heard the composition not phrase by phrase as it was to be written, but in one great burst of sound. The whole psychology of premonition deserves experimental analysis and description. It is intimately connected not only with the problem of anticipatory responses and systematized reaction in speech and reading and music, but as Hull and others have pointed out, with such concrete experimental situations as maze learning and driving an automobile. It is probably also connected with wit, mental disease and the normal conduct of life.

Not essentially different, but only different in emphasis is a third variety in which both stimuli and reactions are systematized. This is exemplified in my experiments in the development of adequate pursuit movements of the eye. The first phase of such pursuit is a period of relatively uncoordinated approximations to pursuit, with inadequate pursuit reactions of the eye and long and frequent corrections. The second phase of such pursuit in response to an oscillating object is regularly much more nearly adequate with less extensive correction than the first. From then on stimulus and reaction are so systematized that the curves of pursuit are almost smooth. Much of our everyday adjustment to events as they transpire involves an exploitation of available behavior systems, corresponding to habits, in reaction to a systematization of stimuli, corresponding to experience.

In view of what we have said concerning the rela-

tion between stimulus and reaction we may now insist that all three varieties of systematization are equally neural. It is a fallacy to think of any known systematization as being external to mind. That is a naïve and uncritical philosophical assumption. The system of physical events that we naïvely think of as the external stimuli for the neural reactions of Mr. X is our own system and the extrojected product of our neural integration. But so is the system of Mr. X's reactions. Both systems depend on the integrating capacity of the same organism, namely, ourselves.

Available techniques for the experimental investigation of neural systems are quite inadequate. Gross extirpation can never settle the question of intranuclear systematization. It deals primarily with the interplay of the various neural levels. The problem of organization at each level calls for the further refinement and extension of such methods as those used by Hess, Dusser de Barenne and the Sherrington school. I believe it also calls for new techniques.

Differential Thresholds

Psychology is concerned with neural systematizations as they appear in the variable patterns of experience, behavior and personality. In many instances the psychological aspects are the only available indications of the neural systems. While references from a single indicator are necessarily indeterminate, we can say at least that the neural integrations must be adequate for the psychological systems. Further—certain analogues of peripheral and internuclear organization probably extend to intranuclear systems. We have dealt elsewhere with the possible rôle of physiological barriers to repetition. Negative adaptation, relative fatigue, summation, facilitation, reinforcement, inhibition, rivalry and competition are all old stories. Our conjectures as to the consequences of these factors are capable of experimental investigation in connection with psychological systematization and resystematization. Some progress is fresh in your minds. On this occasion we would emphasize one more factor, the determination of spread in a group of vital reactors by their casual or persistent differential threshold.

We are still woefully ignorant of most of the details of how this principle cooperates with the others, and while hypotheses that grow out of ignorance are apt to be both tedious and trivial, there are certain reasonable expectations that grow out of experimental experience. First there is a well-documented doctrine of a differential and finally limited spread of neural reactions from any focus to physically and spatially remote areas of the central neural system. One comes to expect more or less extensive spread of neural reaction to every stimulus from inside as well as outside the organism. Second, the spread of neural reactions tends to conform to systems more or less stable and more or less variable, according to the capacities of central neural tissue for persistent integration and reintegration. As the details of some of those spreads and systems are gradually coming to be known from clinical, neurological and psychophysiological data they appear in general to be vastly more complex than might be expected from the mere observation of overt behavior. Even the simplest overt acts, like the knee jerk, the lid reflex and the eye movements, give evidence of extensive neural stimulation-reaction spreads and complex systematizations or response. In many other cases the details are entirely lacking. In such cases explanatory conjectures seem to be quite out of place in any thought that aims to be scientific. Working hypotheses on the other hand, with possibilities of experimental test, are always in order and hypotheses summarizing the available facts tend to focus the outstanding problems.

So, entirely without specific neurological hypotheses, without presuming to have new information with respect to conditions or ultimate processes, we would raise a few suggestive questions with regard to the effects of a differentiatial threshold on neural systematization and resystematization. If we inquire how any of the various modifiers of neural behavior become effective we must again answer honestly that we do not know the details, but that the only principle that fits in with our knowledge of the general physiology of living tissue is that they are all a part of a general plan, effecting some change in irritability of living tissue. The fundamental measure and expression of that irritability is the threshold. Each implies the other. Any natural or developed agreement in neural threshold must necessarily eventuate in a kind of neural system. Any change in a differential threshold must effect change in the relevant systems.

We know some such changes in threshold. They appear in normal sleep, fatigue and normal daily rhythm, in fever, in intoxication by various drugs such as ether, chloroform and alcohol, in lack of oxygen, in the effects of accumulated by-products of bacterial invasion, secretions of the ductless glands. There can be no extensive change of thresholds in neural systems without some change in consciousness or behavior, or both. Would not a general raising of threshold give rise to some such phenomena as we know in tolerance, negative adaptation, in apathy and hypo-excitability as well as in curtailed spread. If the change in irritability is uneven or skewed, systems must result which are lacking in some of the characteristics of normal reaction. Would not a gen-

eral lowering of the threshold eventuate in such phenomena as hyperexcitability, hyperactivity and increased variability; differential lowering, in fixed ideas, anancastic behavior, stereotypy and more serious disequilibrium?

One may also ask in passing what would be the effect of a low threshold of some natural system, such as sex or fear. I remember a patient for whom every situation was terrifying. She could give no adequate reason for being afraid in the staff meeting. "The doctors might torture me," but she didn't really expect they would. Their interested and sympathetic presence, like familiar street noises and less known situations, all indiscriminately evoked fear. The case, like most others, was perplexing enough in its details of diagnosis and treatment, but the main overt symptom was clear and clearly threatened a serious neurosis. If only there was available some specific drug that acted to raise the threshold of the fear system, that particular symptom might have been controlled. Instead, one must seek to control it and its reinforcing systems by some kind of reeducation, possibly with the aid of a general depressant of irritability.

As Freud and his pupils have pointed out, hyperexcitability of a specific sex system represents one of the most common sources of mental unbalance. But, exaggerated egotism and exaggerated feeling of inferiority, suspicion of infidelity, financial worry, hypochondria or any other hyperexcitable system may do almost equally as much harm in promoting unbalance.

Would not a general lowering of the threshold of the sex system tend to a spread of excitation to those systems from all sorts of remotely related stimuli with the definite expectation of such phenomena as fetishism, promiscuity, Sadism, masochism, homosexuality and other abnormal systematizations of the sex life?

I am not suggesting any general principle of explanation but merely asking what would be the tendencies of abnormal excitability of any factor. The known tendency of neural excitation to spread to remote areas of the nervous system make it doubtful if any conditioned reaction represents an entirely new nervous connection. The commoner event probably is that directions of normal spread become emphasized and dominant, according to the principles of facilitation and inhibition that have been elaborately investigated by Pavlov and his pupils. The concept of emphatic or dominant neural bonds is not new. It dates back at least to Wundt's far-sighted analysis of the probable neural systems involved in speech. Recent psychoneurological experiments and clinical experience seem to confirm the soundness of his fundamental ideas.

The so-called anticipatory reaction now appears in a different light. Each case is really a phase of the reactive flux that arises from the systematic changes in threshold of some system leading to a spread of neural action to physiological neighbors before the suppositious specific external stimulus occurs.

This may follow the "conditioned reflex" schema. It may follow the plan of a neural short-circuiting of a series of external stimuli, as in Hull's analysis, but it is not conditioned alone by the sequence of external events. It may follow the course of logical or paralogical thinking or the invention of genius. It must follow the regular or irregular spread of neural impulse in central neural tissue according to the principle of a differential threshold.

A HISTORY OF THE NATIONAL RESEARCH COUNCIL 1919--1933

IX. RESEARCH INFORMATION SERVICE[1]

By Dr. C. J. WEST

DIRECTOR

THE Research Information Service, in its present organization, is a committee of the Executive Board of the National Research Council, the main functional activities of which are: cooperation with the divisions of the Council through inter-office service, and the preparation of compilations which may be used as source books of a general scientific nature. Originally conceived as a war measure, it has passed through several forms of activity, an outline of which will present briefly the scope of its accomplishments.

The following persons, under various titles, have been responsible for the conduct of the Service since its organization in 1918:

1918 —Graham Edgar, *Executive Secretary*
1919–1924—Robert M. Yerkes, *Chairman*
1924–1925—J. David Thompson, *Director*
1925–1933—C. J. West, *Director*

In December, 1917, by joint action, the Secretaries of War and Navy, with the approval of the Council

[1] This is the ninth of a series of ten articles prepared to describe briefly the nature of the activities with which the National Research Council has been engaged during the past fourteen years.

of National Defense, authorized and approved the organization, through the National Research Council, of a Research Information Committee in Washington, with branch committees in Paris and London, and later in Rome. The work of the committee, in cooperation with the Office of Military and Naval Intelligence, consisted in securing, classifying and disseminating scientific, technical and industrial research information, especially relating to war problems, and the interchange of such information between the allies in Europe and the United States.

With the signing of the Armistice, this type of service was no longer needed. The Research Information Committee then was reorganized as the Research Information Service, and its aims and activities became more adapted to the nation at peace. It undertook in the furtherance of its new aim, to be a national center of information concerning research work and workers, to keep in close touch with research activities in educational, industrial and governmental institutions, and with current work and projects in the natural sciences. It offered its services to all those interested in the advancement of science and technology.

But after a few years, during which a number of excellent projects were instituted, it became clear that such a plan could not be carried out without large sums of money. Requests for scientific and technical information were received in great numbers, ranging over all the sciences. This necessitated having on the staff specialists to handle them efficiently; and a large clerical force was needed for the files (as information to *be* information must be accessible).

Difficulties such as these grew more apparent, and in 1923 the idea of a clearing house was abandoned, and a smaller staff set to work in a more limited field of compilation and inter-office cooperation. The number of requests was allowed to decrease, and from that time on the emphasis was definitely placed on the compilation of material of general scientific nature.

Before presenting the work of the Service to-day, it should be said that many of the compilations now prepared annually, or revised from time to time, originated in the days of the larger organization, but an effort has consistently been made, even with a depleted staff, to continue those which seem to have found a niche in the laboratory or library.

As soon as information is collected in the Research Information Service, it is compiled and published either as a circular or bulletin of the National Research Council or in the scientific press, and is henceforth available to the public at all times.

Perhaps there is no better way of describing the present activities of the Research Information Service than to give a brief résumé of the publications which it issues, and in the compilation of which the large part of its time is consumed.

In 1920 a list of research laboratories in industrial establishments[2] of the United States was compiled and published by the Council. The list, containing about 300 names, was avowedly incomplete, but it was felt that the interest aroused in the subject, as well as expected progress in research, would make a revision necessary in a relatively short time. This was proven true by subsequent events, and from 1920 to 1932 there were four editions issued, each one with an increasing number of laboratories, until in the last edition of 1932 there were 1,600 names. All these additions were not necessarily new laboratories, some having been inadvertently overlooked in previous publications; therefore no conclusions should be drawn as to the growth of industrial research from this increase. The 5th edition is now in progress. It will be of interest to note the effect of the present economic situation on the continuance of research.

The Research Information Service has compiled two bibliographies on industrial research,[3] the first covering the years to 1920, and the next from 1926 to 1930. The intervening years were covered by a publication on the subject issued by the Division of Engineering.

The compilation of information on "Funds Available in the United States for the Encouragement of Research"[4] grew out of the frequently recurring requests for financial help in scientific projects. Such funds are in the form of fellowships and scholarships, grants-in-aid, institutional and departmental funds, prizes and medals. The bulletin endeavored to give the names of the various funds, their purposes and amounts. Revision of this was made in 1928.

After the first issue in 1920 the material on fellowships and scholarships was revised as a separate bulletin[5] and two editions issued, bringing the data

[2] "Industrial Research Laboratories of the United States, Including Consulting Research Laboratories," 85 pp. Compiled by A. D. Flinn. 1930. Second edition, 135 pp., revised and enlarged by Ruth Cobb. 1921. Third edition, 153 pp., revised by C. J. West and Ervye Risher. 1927. Fourth edition, 267 pp., revised by C. J. West and Callie Hull. 1931. Fifth edition, revised by C. J. West and Callie Hull. *In preparation.* (Bulletins Nos. 2, 16, 60 and 81.)

[3] "A Reading List on Scientific and Industrial Research and the Service of the Chemist to Industry," 45 pp. Compiled by C. J. West. 1920. (Reprint and Circular Series No. 9.) "Five Years of Research in Industry, 1926–1930: a Reading List," 91 pp. Compiled by C. J. West. 1930.

[4] "Funds Available in the United States of America for the Encouragement of Scientific Research," 81 pp. Compiled by Callie Hull. 1921. Second edition, 90 pp., compiled by Callie Hull and C. J. West. 1928. (Bulletins Nos. 9 and 66.)

[5] "Fellowships and Scholarships for Advanced Work

up to 1929. There has also been compiled each year since 1929, for publication in the *News Edition* of *Industrial and Engineering Chemistry,* a list of fellowships and scholarships supported by industry,—an interesting light on the importance given to such projects by the industrial concerns themselves.

There seemed to be an increasing need among those interested in science for information concerning the societies of the country; so in 1927 a "Handbook of Scientific and Technical Societies of the United States and Canada"[6] was issued. This bulletin listed 793 associations in the United States alone. The National Research Council of Canada cooperated by compiling information for that country, listing 91. The interpretation of a scientific or technical society, for the purpose of this bulletin, was one which contributed to the progress of science through publications or funds for research. The latest edition of this compilation appeared in 1930.

One of the most extensive projects undertaken by the Service has been the compilation by a number of persons of bibliographies of bibliographies in the sciences.[7] The first one of this series issued was a "Catalogue of Published Bibliographies in Geology, 1896–1920," the second a "Bibliography of Bibliographies in Chemistry," to which two supplements have been added, bringing the information up to 1932. A "Classified List of Published Bibliographies in Physics, 1910–1922" was followed by a "Bibliography of Bibliographies in Psychology," and one for medicine is now in progress.

From 1923 to 1924 there were issued lists of bibliographies[8] in manuscript form, and therefore available only upon application to their compilers. These covered the subjects of geology, chemistry, mathematics, physics, astronomy and biology. They were useful as guides to research problems under way as well as for bibliographic reference, but the expense of assembling the information prohibited revisions.

There are a number of compilations which the Service has published annually: Doctorates conferred in the sciences by American Universities,[9] a classified list giving the name of the recipient, the university granting the degree and the title of the thesis. "A Census of Graduate Students in Chemistry in American Universities,"[10] originally begun in 1924 by the Division of Chemistry, was taken over in 1926 by the Research Information Service. This tabular compilation shows the trend of research in universities by a statistical summary of the number of graduate students in each institution according to the branch of chemistry in which they are working. The ninth census is now in progress.

Another project originating in the Division of Chemistry but now in the hands of the Service is the editing of the "Annual Survey of American Chemistry."[11] It contains hundreds of references to the literature of the current year and gives brief descriptions of the work accomplished. Author and subject indexes are included.

There are certain publications which are not issued as Council bulletins or reprints, but which appear in the scientific and technical press, or are published in connection with scientific bodies. One of these is the "Location List of Periodicals Abstracted by Chemical Abstracts,"[12] a cooperative project with the office of *Chemical Abstracts,* three times undertaken by Research Information Service. *Chemical Abstracts* pub-

in Science and Technology,'' 94 pp. Compiled by Research Information Service. 1923. Second edition, 154 pp., compiled by Callie Hull and C. J. West. 1929. (Bulletins Nos. 38 and 72.)

[6] ''Handbook of Scientific and Technical Societies and Institutions of the United States and Canada,'' 304 pp. American section compiled by C. J. West and Callie Hull. Canadian section compiled by National Research Council, Canada. 1927. Second edition, 352 pp., 1930. (Bulletins Nos. 58 and 76.)

[7] ''Catalogue of Published Bibliographies in Geology, 1896–1920,'' 228 pp. Compiled by Edward B. Mathews. 1923. (Bulletin No. 36.) ''Classified List of Published Bibliographies in Physics, 1910–1922,'' 102 pp. Compiled by K. K. Darrow. 1924. (Bulletin No. 47.) ''Bibliography of Bibliographies on Chemistry and Chemical Technology, 1900–1924,'' 308 pp. Compiled by C. J. West and D. D. Berolzheimer. 1925. First supplement, 1924–1928, 161 pp. 1929. Second supplement, 1929–1931, 150 pp. (Bulletins Nos. 50, 71 and 86.) ''Bibliography of Bibliographies on Psychology, 1900–1927,'' 90 pp. Compiled by C. M. Louttit. 1928. (Bulletin No. 65.)

[8] ''List of Manuscript Bibliographies in Geology and Geography,'' 17 pp. Compiled by Homer P. Little. 1922. (Reprint and Circular Series No. 27.) ''List of Manuscript Bibliographies in Chemistry and Chemical Technology,'' 17 pp. Compiled by C. J. West and Callie Hull. 1922. (Reprint and Circular Series No. 36.) ''List of Manuscript Bibliographies in Astronomy, Mathematics and Physics,'' 14 pp. Compiled by C. J. West and Callie Hull. 1923. (Reprint and Circular Series No. 41.) ''List of Manuscript Bibliographies in the Biological Sciences,'' 51 pp. Compiled by C. J. West and Callie Hull. 1923. (Reprint and Circular Series No. 45.)

[9] ''Doctorates Conferred in the Sciences by American Universities.'' Compiled by C. J. West and Callie Hull. 1920–1923, 1926–1932. (Reprint and Circular Series Nos. 12, 26, 42, 75, 80, 86, 91, 95, 101 and 104.)

[10] ''Census of Graduate Research Students in Chemistry,'' 4 pp. Compiled by J. E. Zanetti. 1924. Second census, 3 pp., compiled by J. F. Norris. 1925. Third to eighth census, compiled by C. J. West and Callie Hull, 1927–1932. (Reprint and Circular Series Nos. 54, 63, 79, and 84.) Later ones in *The Journal of Chemical Education,* 6: 1388, 1929; 7: 1674, 1930; 8: 1374, 1931; 9: 1472, 1932.

[11] ''Annual Survey of American Chemistry.'' Vols. 1–7. New York: Chemical Catalog Company, 1926–1932.

[12] ''List of Periodicals Abstracted by *Chemical Abstracts,* with Key to Library Files and Other Information.'' Columbus, Ohio: American Chemical Society, 1922, 1926 and 1931.

lishes the list of journals, but all data concerning the library facilities are obtained and compiled by this office. It is a valuable aid to research workers.

An *Index* to the seven volumes of *International Critical Tables* has recently been completed and will be ready for distribution by April 1, 1933. The *Index* was made in this office, the director of the Service being one of the associate editors of the *Tables*. The *Index* is a volume of 323 pages and contains about 42,000 references and 9,000 cross references. It will be a great asset to users of the *Tables*.

These are examples of the type of compilation in which the Research Information Service is now engaged. No attempt has been made to list all the publications for which it has been responsible. A complete list of these may be obtained from the Publications Office of the Council.

The Research Information Service has always had a very definite conception of its responsibility to the divisions of the Council. It has therefore cooperated at all times in furnishing information when called upon, has acted as agent in obtaining books from outside libraries, and maintains a small but valuable library of source books, such as abstract journals, periodical bibliographies, and reference material. No attempt has been made to go outside this limited field, but it is fitting to acknowledge at this time the indebtedness of the Service to the government libraries which are so generous in lending their books upon request.

SCIENTIFIC EVENTS

THE LEVERHULME SCHOLARSHIPS

As announced in the London *Times*, the trustees of the will of the first Lord Leverhulme, who died in 1925, have decided to devote £12,000 a year to the establishment of a scheme of research fellowships which are intended in the first instance for the assistance of experienced workers rather than to add to the provision already existing for workers in the early stages of their careers.

A statement has now been issued by the advisory committee which was appointed to select the fellows and for the general supervision of the scheme, and the committee reports that from the applications received 17 selections have been made by the advisory committee and approved by the trustees of the will of the late Lord Leverhulme and are for varying periods up to two years. The names of the fellows in the sciences and the subjects of the researches are as follows:

E. C. BULLARD, B.A., Ph.D., demonstrator in geodesy, University of Cambridge.—"Gravity and magnetic measurements." Research to be carried out in Great Rift Valley, East Africa.

C. R. BURCH, B.A. (Cantab.), physicist, Metropolitan-Vickers Electrical Company, Limited.—"On the production of aspherical optical surfaces and on their imaging properties in combination."

F. FRASER-DARLING, Ph.D., chief officer, Imperial Bureau Animal Genetics, Edinburgh.—"An ecological study of a herd of Scottish red deer, with special reference to behavior."

C. S. ELTON, M.A., director of Bureau of Animal Population, University of Oxford, and university demonstrator in zoology.—"Fluctuations in numbers of wild mammal populations."

D. H. HAMMICK, M.A., fellow and tutor, Oriel College, Oxford.—"Investigations on the interaction of nitro-compounds with aromatic bases and hydrocarbons."

H. S. HATFIELD, Ph.D., London.—"The behavior of crystalline substances in electric and magnetic fields."

L. S. B. LEAKEY, M.A., Ph.D., F.S.A., fellow of St. John's College, Cambridge.—"The pre-history of East Africa."

D. L. R. LORIMER, C.I.E., M.R.A.S., F.R.G.S., lieutenant-colonel, Indian Army (retired), late of Foreign and Political Department.—"Anthropological and linguistic research in the Gilgit region of the Karakorum and Hindukush."

A. G. LOWNDES, M.A., Marlborough College, Wilts.—"The polygraphic process. Ultra-rapid cinema photomicrography."

MISS J. A. WALES, employment officer in the Ministry of Labor, secretary to Chelsea and Fulham Juvenile Advisory Committee.—"The study of methods of vocational guidance for young people, as at present used in Germany."

W. F. K. WYNNE-JONES, B.Sc., lecturer in physical chemistry, University of Reading.—"The nature of acids and bases."

AGRICULTURAL REORGANIZATION IN MEXICO

IT is reported by Science Service that the most radical reorganization of the Ministry of Agriculture in Mexico's history along scientific, social and economic bases has been planned by government officials and technical experts, in an effort to turn national agriculture from its haphazard development of the past into directed channels.

Mexico is fundamentally an agricultural country, and yet imports fundamental food that she can raise herself. Her agricultural sanitation is so defective that she often can not sell her products to the United States or other countries. Although her location in the semi-tropics and tropics makes agricultural possibilities almost unlimited, most of the best lands are not advantageously utilized. To correct these and other defects, the federal government hopes to take her national agriculture in hand, direct it economically, socially and technically. This will be easier to

do than in a country like the United States, because Mexico's government has always been paternal, and central authority the rule, and harder, because the government will have more primitive communities and individuals to deal with.

A national Agricultural Advisory Council, made up of representatives of rural organizations of various classes, of state and federal representatives and of technicians, will direct major agricultural policies, directly under a cabinet member. Four scientific bureaus will divide up the work aside from administrative bureaus to carry out the results of their investigations.

A Bureau of Geography, Meteorology and Hydrology will study physical outlines of the country with a view to agricultural application, and map and explore inaccurately known parts. A Bureau of Agricultural Improvement will study the application of vegetable and animal genetics, pest fighting and the like with a view to improving quality and quantity of products, and other factors tending to that purpose. A Bureau of National Lands and Colonization will administer the parceling out and exploitation of lands reclaimed in recent irrigation works; the better distribution of rural population, utilization of desirable regions now abandoned, and the like. In this bureau ethnological surveys and studies of rural sociology will be made. A Bureau of Agricultural Economy will compile statistics, plan programs of agricultural betterment, distribution, consumption and control of production.

THE SOUTHERN CALIFORNIA RIFT CLUB

THE twenty-second meeting of the Southern California Rift Club, an informal organization intended to familiarize southern Californians with the innumerable rifts which divide and subdivide their part of the Golden State into deep blocks of earth-crust, involved a two-day excursion going to and returning from a point on the northern slope of the San Bernardino Mountains overlooking the Mohave Desert. The outward trip was made northward through the Cajon Pass between the San Gabriel and the San Bernardino mountains; and then eastward near the base of the latter range and across the aggraded Lucerne intermont basin, which centers in an extensive playa; finally up a side road on the mountain flanks to a deserted mine, the bare buildings of which the party was allowed to occupy for the night.

Some sixty-three members gathered there in twenty-six automobiles, under the leadership of A. O. Woodford, professor of geology at Pomona College, who in the evening gave an informal account of the huge landslide which is outspread at the mountain base, where it covers an area of six or eight square miles. The next morning the great scar on the mountain side left by the slide was examined. Then, descending over the slide, the longer return trip was begun; first continuing eastward near the mountain base, where Professor W. M. Davis described the greatly degraded surfaces which there characterize the desert; then turning southward to the deep Morongo Valley at the east end of the range, where heavy "Louderbacks" were seen high on its slopes; and thus was reached the heavily aggraded pass between the San Bernardino and the San Jacinto mountains which opened a westward and homeward route. The distance covered by most of the members of the excursion was about two hundred miles. An autumn excursion is planned for September 24 to the Charlton Flats, an uplifted lowland of subdued relief which now, deeply dissected, makes part of the San Gabriel Mountains north of Pasadena.

THE EXHIBIT OF THE BUREAU OF FISHERIES AT THE CENTURY OF PROGRESS EXPOSITION

THE Bureau of Fisheries has an exhibit in the south wing of the United States Government Building at "A Century of Progress" in Chicago. The display cases are made in the modern style of architecture designated for all bureaus of the Department of Commerce, to conform with the general architectural scheme of the fair. These cases are painted with natural pearl essence paint, which is made from fish scales.

At the front of the space allotted to the bureau and on each side are two aquaria containing species of fish propagated at the hatcheries; and in the center is a display of packaged quick-frozen fish and shellfish. The latter display was made possible through the cooperation of several firms which prepare these products.

In the center of the exhibit are four cases which have displays on two sides. In three of them are dioramas; one showing a typical trout hatchery, another modern oyster culture and the third the nutritive value of marine products. On the other side of the cases which contain the dioramas are illustrated the fresh-water mussel fishery and industry, oyster propagation and seed collection, and a display of packaged fish with charts showing the vitamin content of various fish oils and the amount of iodine in certain fish. The fourth case exhibits on one side a model of a Great Lakes pound net and gill net with pictures showing the method of fishing these nets, and the method of determining the age of different species of fish from their scales. On the other side of this case is graphically displayed the bureau's research on the preservation of fish nets.

At the back of the exhibit space are three large

paintings entitled: "Nature's Creations," "Man's Despoliation" and "Science's Restoration." Below these pictures and extending out a few feet in front is a rock garden and pool. To one side is a working model of a fish ladder, while on the other side is a model of a fish lock or elevator. Water running from the two models flows into a central pool in which are various fish and aquatic plants.

On the north wall is a large painting entitled "The Angler," while on each side of this are two cases exhibiting fishing tackle suitable for salt water, surf, bass and trout fishing. This tackle was supplied by various tackle manufacturers. Above the painting and tackle cases are nine transparencies showing views of various hatcheries of the bureau and of oyster culture.

There are three large cases against the south wall. The story of the utilization of fishery by-products of one hundred years ago and at the present time is told in one, while the next exhibits dyed and dressed sealskins and the beneficial effect of the North Pacific Seal Treaty on the Pribilof seal herd. The third case gives a résumé of biological fishery research work of the bureau, especially as to the methods used in deep sea investigations, fish tagging and on the study of the composition of the mackerel catch for the last ten years. Over these cases also are transparencies, depicting various activities of the bureau.

OBITUARY

DR. ELEANOR ACHESON MCCULLOCH GAMBLE, professor of psychology at Wellesley College, died on August 30, at the age of sixty-five years.

JOHN BENTLEY, JR., professor of forest engineering at Cornell University since 1917 and a member of the faculty since 1912, died on July 26, at the age of fifty-three years.

EDWARD ROBERTS, formerly of the British Nautical Almanac office, known especially for his work in the practical development of tidal prediction, died on August 4 at the age of eighty-eight years.

A WIRELESS message announcing the death of Dr. M. O. Malta has been received at Ottawa. Dr. Malta, who was a native of Sweden and for the past thirty years research botanist of the Federal Government, was taken ill suddenly while on an Arctic expedition.

SIR PHILIP MAGNUS, formerly Conservative member of the House of Commons for London University, an authority on mechanics, hydrostatics, mathematics and technical education, died on August 29. He was eighty years old. Sir Philip, until he retired in 1925, was a lecturer on mathematics and science at London University and at colleges and universities throughout the United Kingdom.

SCIENTIFIC NOTES AND NEWS

THE British Association for the Advancement of Science is meeting in Leicester from September 6 to 13. The address of the president, Sir Frederick Gowland Hopkins, which will be printed in SCIENCE, is entitled "Some Chemical Aspects of Life." In addition to the arrangements for the meeting reported in the issue of SCIENCE for May 19, it is announced that there will be discussions on atomic transmutation, to be opened by Lord Rutherford, and on the expanding universe, to be opened by Sir Arthur Eddington.

DR. JAMES BRYANT CONANT took up his work as the twenty-fifth president of Harvard University on September 1. The formal inauguration will take place on the twenty-fifth of this month. Prior to his election to the presidency Dr. Conant was Sheldon Emery professor of organic chemistry.

A SPECIAL tribute on the occasion of his eightieth birthday will be paid to Dr. Karl Sudhoff, professor of the history of medicine at Leipzig, founder of the German Society for the History of Medicine and Natural Science, at its annual meeting at Erfurt on September 9 and 10.

PROFESSOR AUGUST GÄRTNER, formerly professor of hygiene at Jena, recently celebrated his eighty-fifth birthday.

DR. ROCH, professor of clinical medicine at Geneva, and Dr. Haškovec, professor of clinical neurology at Prague, have been elected foreign corresponding members of the Academy of Medicine, Paris.

DR. E. KOHN-ABREST, of Paris, has been elected a foreign corresponding member of the Royal Academy of Medicine of Belgium.

PROFESSOR W. LANGDON BROWN, Regius professor of physic in the University of Cambridge, was recently elected a member of the Atheneum Club under the provisions which empower the annual election of men of distinguished eminence in science, literature, the arts or for public service.

PROFESSOR M. GALE EASTMAN, head of the department of agricultural economics and associate dean, has been named dean of the College of Agriculture at the University of New Hampshire. He succeeds Professor F. W. Taylor, who has been placed in charge of practical farm projects.

FOLLOWING the recent reorganization of curriculum and courses at Bucknell University, the various departments of science and of engineering have been coordinated into two new administrative units. Professor F. M. Simpson has been appointed chairman of the natural science group, and Professor S. C. Ogburn, Jr., chairman of the engineering group.

PROFESSOR H. W. FLOREY, Joseph Hunter professor of pathology in the University of Sheffield, has declined the offer of the Sir William Dunn chair of pathology tenable at Guy's Hospital Medical School, London.

DR. H. P. GILDING has been appointed to succeed Professor I. de Burgh Daly in the chair of physiology at the University of Birmingham.

DR. OTTO GERNGROSS, professor of chemical technology at the University of Berlin, has been appointed professor at the Agricultural School at Angora.

THE *Journal* of the American Medical Association reports that the Robert Koch Institute for Infectious Diseases, in Berlin, originally under the direction of Koch himself, was, for many years, under the directorship of Professor Fred Neufeld, who has become known through his researches on tuberculosis. Professor Karl Friedrich Kleine, who, for many years, has been a department director at the institute, has been appointed his successor. Professor Kleine was one of the intimate collaborators of Robert Koch. He served as director of the crusade against trypanosomiasis in German East Africa and was the first investigator who transmitted sleeping sickness to apes through the natural intermediate host, the tsetse fly.

Nature reports that Dr. D. P. D. Wilkie, professor of surgery in the University of Edinburgh, has been appointed a member of the Medical Research Council in succession to Wilfred Trotter, who retires in rotation on September 30, after four years' service.

DR. ROY CHAPMAN ANDREWS, of the American Museum of Natural History, has returned to the United States after a visit to Europe.

DR. CARLETON S. COON, of Wakefield, Massachusetts, has sailed for Europe. He plans to spend a year in Ethiopia, where he will engage in anthropological research for Harvard University.

DR. WARREN K. MOOREHEAD, director of the archeological department of Phillips Academy at Andover, Massachusetts, and a member of the Committee on State Surveys of the National Research Council, plans to spend the time between October 1 and April 20 in an inspection and study of museum and private archeological collections. His tour will embrace some twenty-six states. The well-known archeological centers will be avoided. Museum curators, students and collectors are requested to correspond with Dr. Moorehead, who will send those interested a copy of his itinerary.

DR. CO CHING CHU, director of the National Research Institute of Meteorology, Nanking, China, is now in the United States. He attended the Fifth Pacific Science Congress, held in Victoria and Vancouver, British Columbia, this summer as an official delegate.

SIR HAROLD HARTLEY, of London, fellow of the Royal Society and vice-president of the London, Midland and Scottish Railway, visited Pittsburgh on August 28 and 29 for the purpose of inspecting the Coal Research Laboratory of the Carnegie Institute of Technology. Sir Harold was brigadier general in the Chemical Warfare Division of the British army during the war. He has been a member of the Fuel Research Board of the Department of Scientific and Industrial Research of Great Britain since its inception and is now its chairman. He is also research director in scientific matters for the London, Midland and Scottish Railway.

PROFESSOR V. KARAPETOFF, of the department of electrical engineering of Cornell University, has been appointed Lieutenant Commander in the Naval Reserve and has been assigned to the Volunteer Naval Reserve for engineering duties.

MAJOR JAMES S. SIMMONS, Major Virgil H. Cornell, Sergeant George F. Luitpold and Sergeant Jesse F. Rhoads, of the U. S. Army Medical Corps, have gone from Washington to St. Louis to study the encephalitis situation.

IN memory of the late Howard W. Estill, D.Sc., assistant professor of bacteriology at the University of California Medical School, Mrs. Estill has given his library to the medical school and the San Francisco branch of the state medical library. The gift includes monographs and reference volumes relating to organic, physical and colloid chemistry as applied to biology and medicine.

A VOLCANOLOGICAL museum founded by Frank A. Perret was opened on August 27 at St. Pierre, in the northern part of the French West Indian island of Martinique. The institution, provided for by American and local contributions, exhibits relics dug from ruins of eruptions of Mt. Pelée and other volcanoes. Mr. Perret, a member of the Volcanic Research Society, of Springfield, Massachusetts, who has conducted research at Mt. Vesuvius, Italy, and Sakurajima, Japan, recently received the decoration of Chevalier of the Legion of Honor from the French government.

APPLICATIONS for the positions of senior engineer,

engineer, associate engineer and assistant engineer must be on file with the U. S. Civil Service Commission at Washington, D. C., not later than September 28. The examinations are to fill vacancies occurring throughout the United States. The entrance salaries range from $2,600 to $5,400 a year, less a deduction of not to exceed 15 per cent. as a measure of economy and a retirement deduction of three and a half per cent. Optional branches are aeronautical, agricultural, civil, construction, electrical, heating and ventilating, highway, mechanical, mining, radio, structural and telephone engineering. Competitors will not be required to report for a written examination, but will be rated on their education and experience.

EVERY regular employee in the field service of the Bureau of Fisheries will be subject to 15 days' administrative furlough during the current fiscal year in order to remain within its 1934 limitations, with the exception of the Alaska vessel service, which will be handled in another manner.

WE learn from *Nature* that there has been a change in the regulations for Part II of the Natural Science Tripos (physics and chemistry) at the University of Cambridge, to take effect in 1934. Under the new regulations, there will be four papers in chemistry: two of a general nature and two more specialized, including questions in inorganic, organic, theoretical and physical chemistry, colloid science, metallurgy and crystal chemistry. A sufficient number of questions will be set for a candidate to attain a first class in one or more of the subdivisions. Four papers will also be set in physics, three being of a general nature. The fourth paper will contain specialized questions on some branches of physics, but a sufficient number of questions on crystallography and crystal physics will be set in this paper to allow a candidate to gain full marks by answering questions on these branches only.

A CORRESPONDENT of the *Journal* of the American Medical Association writes: "On May 27 the jubilee of Professor d'Arsonval was celebrated at the Sorbonne, in the presence of the President of the Republic. Since 1872 this savant, who carries his eighty-two years with youthful nonchalance, has taught at the Collège de France. The public, and to a certain degree even the medical profession, has been ignorant of d'Arsonval's contributions to the sciences of physics and medicine. To many he has just been a name, to still more his name even has been unknown until this present jubilee was made the occasion for short explanatory articles in the medical and lay press. Working on the physiology of the muscles and nerves, he found he had to create new electrical equipment, and as his researches proceeded he conjured up one delicate instrument of precision after another—electrodes, galvanometers, the electric bistoury, etc. The father of diathermy, he has opened out new fields, the therapeutic possibilities of which have not yet been fully explored. In response to the many laudatory addresses delivered in the great amphitheater of the Sorbonne, d'Arsonval, in a simple speech, gave the credit for the influences which had inspired him in his youth to one man and one setting. The man was Claude Bernard, and the setting was the Collège de France. Here, sixty years ago, Claude Bernard made it possible for his youthful pupil to develop those qualities which have yielded such wonderful fruit. After Claude Bernard, d'Arsonval mentioned the names of two men—Marey and Brown-Séquard—to whose inspiration he owed much."

RIDING MOUNTAIN NATIONAL PARK, Canada, officially opened on July 26, was set aside as a playground and animal reserve three years ago. The park, which is wholly within the Province of Manitoba about 100 miles west of Winnipeg on the Canadian National Railways, comprises an area of 1,148 square miles, which is heavily wooded and contains several lakes. Within the park are contained between 2,000 and 3,000 head of wapiti, probably the largest herd in Canada, and also a small herd of buffalo, which is kept in an enclosure of 332 acres. The terrain of the park, although surrounded by prairie, is decidedly rolling and offers a variety of scenery. The roads leading to and within the park have been resurfaced and graded, and the park has been brought up to the standard of the other national parks under the jurisdiction of the Department of the Interior of the Federal Government.

FOR several years the United States Geological Survey and the Pennsylvania Topographic and Geologic Survey have been engaged in making a systematic study of the ground-water resources of the State of Pennsylvania, in order to be able to serve the people of the state more adequately in solving the innumerable problems of municipal, industrial and domestic water supply. In connection with this general program a detailed report has been prepared by S. W. Lohman on the ground-water resources of the northeastern part of the state, including Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Northumberland, Pike, Schuylkill, Susquehanna, Wayne and Wyoming Counties and the northern part of Dauphin and Lebanon Counties. In preparing this report all existing geologic information was utilized, and a large amount of hydrologic information was obtained in regard to more than 1,100 wells. Chemical analyses were made of 106 samples of water collected from wells and springs. Manuscript copies of the report are on file and may be consulted in the offices of the Pennsylvania Topographic and Geologic Survey at Harrisburg and of the U. S. Geological Survey at Washington.

DISCUSSION

OBSERVATIONS ON FORECASTING ANNUAL CHANGES OF CROP YIELDS

IN an era when the control of production of leading crops is a watchword and when the problem of anticipating the output of the land placed under cultivation bears important economic implications, attention can be drawn very properly to changing ideas about the methods of forecasting acre yields.

Interest in making prophecies about the levels of crop yields was stimulated by the extension of higher mathematics to statistical problems. As the processes of multiple correlation became familiar, simple correlation for some unexplained reason remained fashionably taboo for many minds. The time is still not remote when the pursuit of elusive independent weather variables was a favorite indoor sport, and the monthly climatological sheets of the U. S. Weather Bureau provided a convenient hunting ground for the chase. The common practise was to plot an appropriate yield series first against precipitation, then to check the residuals from a fitted line against temperature. If this combination failed to produce the desired results another was tried until, after repeated trials, a reasonably high degree of correlation occasionally was obtained—but more often not! It is probably safe to say that the actual number of cases where success was achieved was few compared to the energy expended. A great deal of time, and in many instances money, was wasted in the blind faith that the magical combination of variables necessary for deriving an efficient regression equation would be discovered on the next search.

The futility of the old hit-or-miss system has given way to a new order of simplicity. All the impressions necessary for arriving at a conclusion are no longer thrown into a complex statistical hopper. The transition was occasioned perhaps more by the limitations of materials worked on than by the tools employed. The conviction grew that the number of the climatological forces, influencing growth and production, which could be taken into account, was insufficient to permit forecasting with confidence. A further restriction appeared in the fact that cases developed in studies on several crops where sets of independent weather variables were numerically the same or nearly so in different years, and yet the yields of these years were substantially unequal. This circumstance indicated the possibility that the degree of relationship between yield and factors regarded as being associated with it was changing with the passage of time.

Shifting correlation is a hurdle difficult to surmount whenever it occurs, but is especially perplexing in crop forecasting problems which deal with the weather. The hope may be expressed that research directed toward the isolation of definite climatic cycles eventually may throw some light on the causes of this statistical disturbance and indicate a means of coping with it. Meanwhile practical forecasting must proceed along lines of common sense and be devoid of ill-advised efforts to achieve by weird demonstrations of high-powered curve fitting what is at present impossible.

Current procedure in forecasting represents both statistical and non-statistical judgment. A single weather series is used in a simple correlation set-up with yield. The prediction arising therefrom is then modified as information comes from the growing area concerning crop conditions. The accuracy which is obtained by use of this system—embracing to an appreciable extent both quantitative and qualitative conclusions—compares favorably with the results formerly obtained. It is probably safe to say that the experienced estimator can amass a creditable record for having his prophecies come true within reasonable limits without resorting to the use of complicated technique at all.

Several years ago the writer discovered that a valuable preliminary impression for making a forecast frequently can be obtained months before weather information is available or the crop is even planted. This can be accomplished by taking advantage of the existence of negative correlation between the ratio of the yields of two successive years (dependent variable) and the yield of the first of these years (independent variable). A regression line is fitted to a suitable number of observations. The line is of the form $\frac{y}{x} = a - bx$, in which y = the yield of a specified year, x = the yield one year preceding, and a and b are constants to be determined. Usually when a ratio is correlated with one of its own elements, as in certain physical problems, the numerator and denominator are of different basic series. In the present case, although taken a year apart, they are both of the same series. The distinctive character of this type of relationship suggests that it may be designated appropriately by the term auto-variation.

Sometimes the relationship established between the variables, by use of such simple technique, is very favorable. For example, a study of the acre yields of flue-cured tobacco (Old Belt, Type 11), as published by the U. S. Department of Agriculture for the period 1910–1931, revealed a coefficient of correlation of -0.895 after the removal of secular trends. No extravagant claims are made, however, about the application of the principle of auto-variation to crop forecasting problems. It is used merely as one basis for formulating a judgment. The writer has experi-

mented with it in about 25 different cases involving tobacco, cotton, wheat and corn. Presumably it can be extended to other crops. In every case where it has been tested the ratio of the yields of two successive years and not the absolute yield of the second year has served as the dependent variable. If for some reason primary statistical interest should rest on the absolute yield, instead of the annual change, the method outlined would have to be modified and a curve of the form $y = ax - bx^2$ fitted to the observed data. In actual practise the need hardly arises for following this alternative procedure.

Simplifications which have been effected in the technique of forecasting still leave ample ground for further improvement. Econometricians familiar with this field perceive that the day is not yet in sight when the extent of an annual crop change can be foretold with anything like complete accuracy. The results of climatological investigations eventually may help to clarify the reasons for errors which are made. Measurements of the periodicities of possible component curves of the total solar energy curve by Dr. C. G. Abbot, of the Smithsonian Institution, are being regarded in a sympathetically critical and hopeful spirit. Likewise the studies of Dr. A. E. Douglass, of the University of Arizona, on tree rings as a medium for determining annual growth variations of the past, and of the staff of the Scripps Institution of Oceanography of the University of California on the relationship between ocean temperatures and solar energy, are being watched with interest. The suspicion persists that if the research of these and other investigators should lead ultimately to the development of long-range weather forecasting on a practical basis, long-range crop forecasting also may follow. In that event both the old methods of predicting crop yield changes and those lately developed will be revealed at best as being only makeshift attempts.

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IS METHYLENE-BLUE ANTI-CARCINOGENIC?

WARBURG[1] in his study of yeast found methylene-blue to counteract the effect of carbon monoxide and potassium cyanide. This protective action of methylene blue upon the respiratory enzymes was extended by Sahlin,[2] Eddy[3] and Brooks[4] to small mammals, and ultimately by Geiger[5] to human cases.

Now, as already shown,[6] malignant growth is based upon the suppression of respiratory enzyme (oxidase-dehydrogenase) activity by (a) dietary enzyme depletion and (b) environmental inhibition.

In cases where malignant growth is dominated by such specific industrial conditions as the effect of coal-tar and mineral oils, we find the respiratory enzymes are influenced by definite carcinogenic substances such as 1:2:5:6 Dibenzanthracene, 5:6 cyclo-penteno, 1:2 Benzanthracene, 1:2 benzpyrene, etc., the activity of which may perhaps be likewise counteracted by methylene blue.

Some support to such a possibility is afforded by (1) the action of carcinogenic substances upon the dehydrogenase group of enzymes,[7] (2) the existence of anti-carcinogenic substances, as, for example, di-chloro-diethyl sulphide (mustard gas),[8] and (3) the intimate connection existing between respiratory enzymes and certain coloring matters,[9] the function of the latter being that of a co-enzyme rather than substrate.

Bearing in mind the colloidal nature of the enzymes in relation to the whole system of their contact and inductive activity—the characterization of the cancerous cell by its abnormal state of colloidal dispersion and the suggested extension of Bancroft's physico-chemical corrective treatment to such malignant cell colloids[10] is also in full accord with the conception put forward here.

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COURSES IN THE LITERATURE OF BOTANY

FOR several years, the writer has been developing a graduate course entitled "Literature of Botany," the aim being to acquaint advanced students with classic and current literature related to botany. This work has proved both difficult and interesting, having opened new worlds of botanical thought, appreciation and knowledge. Since the work has been crystallizing, it was thought desirable to compare the course with similar courses in other educational institutions. This led to the study of the university and college catalogues which were on file in the Kansas State College library. With few exceptions the 1931–1932 catalogues were available. The institutions which included courses in botany in their curricula totaled 545. Of these, 20 were outside of the United States. Of the 545 institutions, only six offered courses in or including literature of botany as such. These are as follows: University of Montana, "Botanical Literature"; University of Nebraska, "Botanical Literature"; Kansas State College, "Literature of Botany";

1 *Zeits. Physiol. Chem.*, 66: 305, 1910.
2 *Skand. Arch. Physiol.*, 47: 284, 1926.
3 *Jour. Pharm. and Exp. Ther.*, 41: 449, 1931.
4 *Proc. Soc. Exp. Biol. and Med.*, 29: 1228, 1932.
5 SCIENCE, 77: 1986, January 20, 1933.
6 Copisarow, *Nature*, 130: 1001, 1932.
7 Boyland, *Nature*, 130: 274, 1932.
8 Berenblum, *Rep. Brit. Emp. Cancer Camp.*, 76, 1932.
9 Warburg and Christian, *Biochem. Zeits.*, 257: 492, 1933.
10 Crawley, *Jour. Phys. Chem.*, 36: 1282, 1932.

Nebraska Wesleyan states in a seminar course that "topics including botanical literature will be offered according to demand"; Oberlin College, "History and Classics of Botany"; Pittsburgh University, "Comprehensive Survey of Botany."

There were, however, 164 additional related courses offered by 139 of the 545 institutions. In the field of botanical literature, in addition to the 6 courses already mentioned, there were 13 courses covering recent or current literature offered in the form of colloquia, conferences, etc.; 4 courses in the literature of foreign journals and 13 in problems or assigned readings. Twenty-five courses were offered in the history of botany, and one covered modern or contemporary botany and another history of early botany.

In the closely related field of the literature of biology, there were 4 courses under that name; 23 courses covering recent and current literature in seminars, colloquia, conferences; 2 of foreign biological literature; and 8 in biological literature problems. History of biology boasts 38 courses, the largest number, with 19 additional courses covering special histories or theories of biology.

Then there were 11 miscellaneous courses related to the literature of botany, covering such subject-matter as the literature of the sciences, of horticulture, zoology, entomology, or history of inductive sciences, science, agriculture, forestry, life and applied botany. It is interesting to note that only one course is offered in the preparation of biological manuscripts for publication and that one by Lingnan University; also a course in botanical illustration for publication by Washington State College.

While some errors in classification may have crept into this condensed distribution of 170 courses, due to the indefinite nature of the information in certain catalogues, it nevertheless shows that the value of the historical and literary approach to the mastery of the biological sciences has wide acceptance. But this need appears in some measure to be met in only about 25 per cent. (139 out of 545) of the universities and colleges for their advanced students. It seems that this approach should be more widely introduced and not reserved for graduate students only. Certainly the undergraduate, who rarely becomes an advanced student in a biologic subject, should be introduced to the biographic method. Exposure to an occasional superbly illustrated botanical classic may leave a profound impression on a pliant mind. Furthermore, the development of a thought which leads to a demonstrated fact contains more human interest and abiding qualities than a mere dry statement in a drier text.

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ON THE AUDIBILITY OF THE AURORA BOREALIS

THE proposition of the audibility of the aurora borealis has been the subject of considerable speculation and much doubt. Some scientists have claimed with much positiveness that the aurora emits no audible sounds and that the beams of light or electrical waves, such as they may choose to call them, do not come close enough to the earth's surface to be audible, even if any sound were emitted. In my own mind there can be no doubt left as to the audibility of certain types of aurora, for I have heard them under conditions when no other sound could have been interpreted as such, for no other sounds were present.

From the Eskimos I first learned that the aurora could be heard and, like most people, was rather skeptical about it, believing that their statements were based to a great extent on their superstitions. I was told by some of the older Eskimos that when the aurora displays become audible they are able to imitate the sound by whistling in such manner that the beams of light will be attracted or drawn down to them. This, of course, is purely superstition. However, it does bring out the fact that the Eskimos were frequently able to hear the aurora.

The following is my own personal experience which convinced me that the aurora borealis was actually audible. In the winter of 1925–1926 I was engaged in making a drive of reindeer across the mountain range bordering the Arctic coast north of Cape Prince of Wales on Bering Strait. One night during this drive found me traveling by starlight across the divide at the head of Nuluk River. This divide has an elevation of approximately two thousand feet. It was two o'clock in the morning when my native driver and I broke camp in order to overtake the reindeer herd ahead of us. As we climbed with our dog team to the summit of the divide we were both spellbound and astounded by the magnificent display of aurora, the most wonderful display I have ever witnessed during my eight years of life among the Eskimos.

Great beams of light shot up from the northern horizon as if a battery of gigantic searchlights were searching the arctic landscape. In front of these beams and throughout the whole length of the northern horizon great waves of iridescent light traveled from west to east like gigantic draperies before the stage of nature's amphitheater. Great folds or waves, ever changing in color, traveled one after another across the horizon and from behind them streamed the powerful beams of white light. These beams of light could be seen passing directly over our heads, and when one chanced to come over the divide it appeared to be not more than a hundred feet above

the surface. The spectacle was so awe inspiring that the dog team was stopped and I sat upon the sled for more than an hour absorbing the marvelous beauty of this most unusual display. As we sat upon the sled and the great beams passed directly over our heads they emitted a distinctly audible sound which resembled the crackling of steam escaping from a small jet. Possibly the sound would bear a closer resemblance to the cracking sound produced by spraying fine jets of water on a very hot surface of metal. Each streamer or beam of light passed overhead with a rather accurate uniformity of duration. By count it was estimated to require six to eight seconds for a projected beam to pass, while the continuous beam would often emit the sound for a minute or more. This particular display was so brilliant that traces could easily be seen long after daylight.

CLARK M. GARBER

PROFESSOR EINSTEIN AND THE INSTITUTE FOR ADVANCED STUDY

THE statement in your issue of August 18 that Professor Albert Einstein will "spend the *winter half-year* conducting his scientific work at the Institute for Advanced Study" will not be understood in this country, inasmuch as the terminology, "winter half-year," is, as far as I know, not employed in America. The academic year of the Institute for Advanced Study starts at the beginning of October and ends at the beginning of May with an intermission at Christmas. It covers therefore autumn, winter and a part of the spring. On account of a previous commitment to the University of Oxford, Professor Einstein's arrangement with the institute permits him to terminate his work annually at Princeton a fortnight earlier than his associates.

ABRAHAM FLEXNER

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR PERMANENTLY RECORDING THE LOCATIONS OF OBJECTS ON MICROSCOPE SLIDES[1]

MICROSCOPISTS have often felt the need for a method of locating objects on a slide so that they might be found quickly at any time on any microscope. The Maltwood finder, used many years ago, was a step in this direction, but was somewhat awkward to use, particularly if many objects were to be located, and was unsatisfactory when they were very small. Since nearly all modern research microscopes are fitted with graduated mechanical stages, the method of locating objects on a slide by recording their coordinates has become increasingly popular. As ordinarily applied it is open to the following objections:

(1) Objects located with one objective are difficult to find if another objective is used on a revolving nosepiece.

(2) Any shifting of the position of the optic axis with reference to the coordinate system of the mechanical stage likewise shifts the position of all objects recorded in terms of this coordinate system with respect to the optic axis. This shifting may be caused by a faulty revolving nosepiece, by unscrewing and replacing an objective, by an accidental decentering of a centerable revolving stage, or by an accidental decentering of a centerable objective changer.

(3) Objects located on one microscope can not be found easily and definitely when a different microscope is used.

The first two objections can be overcome by employing centerable objective changers, keeping them accurately centered by frequent checking and by frequently checking the centering of the revolving stage. The method here described offers a means of overcoming the third objection.

After a slide has been labeled and numbered, a small cross is made on it with a writing diamond about 2 mm outside the lower left-hand corner of the cover glass. A filing card is provided (4 by 6 inches is a convenient size) for each slide which bears the same serial number and other data pertaining to the slide. On this card the coordinates of objects of interest are recorded as well as the coordinates of the cross. The objects and the cross are thus permanently recorded in terms of the same rectangular coordinate system. By subtracting the coordinates of the cross from those of the objects, the cross becomes the origin of a system of rectangular coordinates, and the differences become the (x', y') of each object. If the slide is placed upon the mechanical stage of another microscope, the coordinates of the cross become a new origin of a second rectangular coordinate system. Adding the above differences (x', y') to the coordinates of this new origin gives the coordinates of the point (x'', y'') on the second microscope. By setting the mechanical stage to these coordinates (x'', y'') the object is found easily.

Difficulty may be experienced when one or both of the scales on one microscope run in opposite directions from those on the other microscope. In this event the differences (x', y') are treated in an opposite manner to the way they would be if the respective scales increased in the same direction; that is, the differences (x', y') are subtracted from the coordinates of the

[1] Published by permission of the director of the U. S. Geological Survey.

cross in the second microscope when they would have been added or *vice versa*. Since the cross lies farther to the left and lower down than any point within the cover glass, any incorrect value for the final coordinates (x″, y″) on account of the scales running in opposite directions will give a point entirely outside the cover glass. Hence the mistake will be immediately evident and easily remedied.

The accuracy of the method depends upon the precision with which the mechanical stages are made and graduated and upon the care with which the coordinates are read and recorded. Except for a few petrographic stages graduated to 0.01 mm, standard mechanical stages, either "built in" or attachable, are graduated to 0.1 mm and can be readily estimated to 0.05 mm. This means that an object can be located within a square 0.05 mm on a side, which, considering the fact that the field of view of a 1.8 mm objective and 10x ocular is 0.2 mm in diameter, is satisfactory even for a very small object. It would help considerably if all microscope manufacturers adopted a uniform system in the graduation of mechanical stages. The two largest manufacturers of microscopes in this country follow the same system for the horizontal movements of their stages, but have the numbers increasing in opposite directions on the vertical movements. The best method would be to have the stages graduated so as to read 0–80 mm from left to right on the horizontal movement and 80–130 from bottom to top on the vertical movement. This would place all the coordinates in the first quadrant, giving positive values. Any other arrangement introduces negative numbers for at least one of the coordinates.

This method has been used by the writer over a period of years and found to be entirely satisfactory. Objects located eleven years ago can be found quickly to-day. Furthermore, the slides, with the necessary data, may be sent to any one having a graduated mechanical stage on his microscope with the assurance that he will find the objects easily by the application of the above method.

K. E. LOHMAN

U. S. GEOLOGICAL SURVEY

AVOIDANCE OF EMULSIFICATION IN DEFATTING OPERATIONS

IN previous work on the fatty oil of digitalis seed[1] difficulty had been experienced in the separation of the fatty oil from the alcoholic concentrate because of the permanence of emulsion formed in shaking the hydroalcoholic extract with petroleum ether. Hence, it was suggested to one of us to try an adaptation of the method long used to remove alkaloids by means of ether or chloroform from solutions with which these alkaloidal solvents are immiscible. Reference is had to the method of allowing these solvents to bubble through the liquid from which the alkaloid is to be removed. The large quantity of concentrated tincture seemed to render the conventional long narrow tube impracticable; hence, a percolator was substituted therefor. To the surprise of the operator, the petroleum ether, when passed into the bottom of the percolator, did not bubble through the hydro-alcoholic fatty extract, but the bubbles quickly blended with the extract it was intended to defat. The result was a solution, though not clear at first. Upon the further addition of petroleum ether a sort of emulsoid resulted. Another surprise was in store when, after the continued addition of petroleum ether, the apparent diphase separated into two layers, the clear petroleum ether solution rising to the top without a trace of emulsification. The addition of petroleum ether which, after the breaking up of the emulsoid, bubbled through the hydro-alcoholic layer of extract was continued until the latter was completely defatted.

In order to ascertain whether this technique is applicable to a wider range of plant products, it was applied to the defatting of a concentrated alcoholic extract of linseed with a high fatty oil content. It was also applied to the removal of the non-saponifiable matter with ether from the aqueous soap solution of milkweed oil. In both instances it proved equally successful. Thinking that the method may prove useful to others who have been annoyed by obstinate emulsions in the defatting of hydro-alcoholic extracts, it is herewith described to be tried out if they see fit.

Fig. 1 shows the set-up before it is placed in operation. Aspirator bottle, A, is filled with petroleum ether. Percolator, P, contains the hydro-alcoholic extract to be defatted, introduced from separatory funnel, D; the amount of hydro-alcoholic extract that can advantageously be defatted in one operation varies with the fat content. It may be best not to fill the percolator more than one third. Screw cock S controls the flow of petroleum ether. Screw cock S_1 enables the draining of the percolator after defatting has taken place. Flask F is used to collect any excess petroleum ether containing fat removed from the alcoholic extract. The washed hydro-alcoholic extract is drained from the bottom of the percolator into flask F_1. After its removal the upper layer of petroleum ether containing dissolved fatty oil can likewise be removed by this means. Separatory funnel D is used to recharge the percolator with fresh hydro-alcoholic concentrate. Tube, T, functions as a syphon removing any excess of fat-containing petroleum ether. It is necessary that cork C fit as tightly as possible; hence it should, if necessary, be sealed with a suitable agent.

As already pointed out, it may prove advantageous not to fill the percolator more than one third. When

[1] S. H. Culter, *Am. Jour. Pharm.*, 102: 545, 1930.

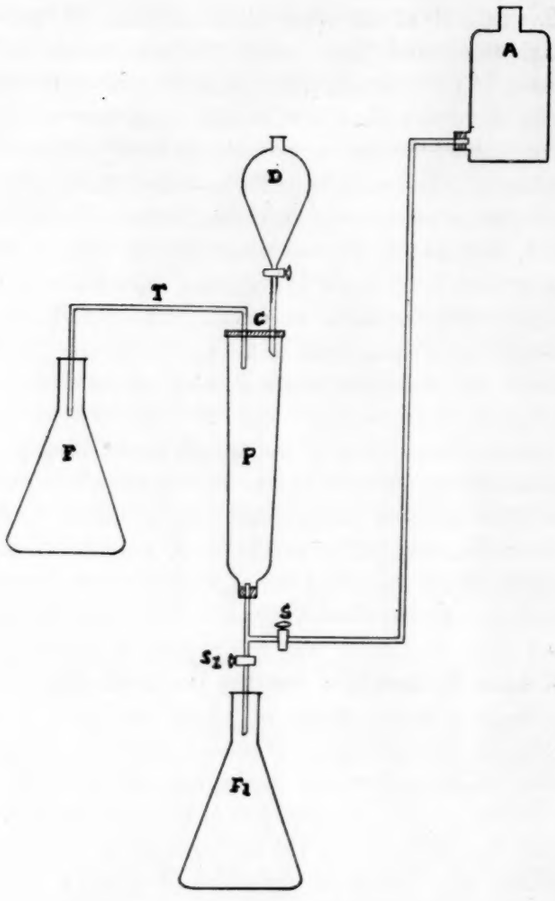

FIG. 1.

the petroleum ether flow was started, it produced a clouding effect at the point of entrance. However, this disappeared almost immediately. Upon further addition of the petroleum ether, the clouding increased gradually until the whole solution was uniformly cloudy, while the volume had increased materially. Evidently, this is the emulsification stage. As more petroleum ether was added to the solution or emulsion, a petroleum ether layer containing fat began to separate above. As still more immiscible solvent was added, the size of the petroleum ether layer increased, whereas that of the lower hydro-alcoholic layer diminished. At the same time the syphon began to function due to the air chamber formed in the top of the percolator. In this manner the excess of the petroleum ether layer was forced out. The bubbling up of petroleum ether through the lower hydro-alcoholic layer was continued until all the fatty oil had been removed. This point can be judged roughly when the petroleum ether that separates is no longer colored. Shortly after the separation of the petroleum ether layer, the lower hydro-alcoholic layer became clear. Upon the addition of more petroleum ether, the original hydro-alcoholic solution receded to a volume slightly below the volume introduced at first.

Continued extraction caused some of the material in the hydro-alcoholic extract, other than fat, to separate out on the walls of the percolator. Hence this method not only served as a means of avoiding emulsification, but also brought about a separation of a third substance, at least in this instance.

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SPECIAL ARTICLES

RELATIONSHIP OF THE VIRUSES OF VESICULAR STOMATITIS AND OF EQUINE ENCEPHALO-MYELITIS

THE virus of equine encephalomyelitis, recovered by Meyer, Haring, and Howitt[1] from affected horses, is regarded by them to be distinct from the incitant of botulism, "forage poisoning," Borna's disease, poliomyelitis, and apparently, from that of enzootic encephalitis of the Moussu-Marchand type.[1,2] In view of the fact that the horse is the natural host for this disease and also for vesicular stomatitis, we undertook a comparison of the properties of the viruses obtained from both infections. We wish to thank Miss B. Howitt, of the George Williams Hooper Foundation of the University of California, for a specimen of the encephalomyelitis virus.

The following series of comparative tests were made:

Intracerebral Inoculation:[3] The intracerebral inoculation of guinea-pigs, white mice, *Macacus rhesus* and *cynomolgus* monkeys with either virus induces in each instance fatal encephalomyelitis,[4] characterized usually by the same period of incubation and set of symptoms. The rabbit, however, is much more resistant to the two viruses than the other animals mentioned, and 24 to 48 hour old chicks are unaffected by them. The viruses can be recovered from the submaxillary and parotid glands, blood, brain, spinal fluid, lung, spleen, liver and kidney of monkeys, guinea-pigs, and mice experimentally inoculated with either one. The gross and microscopic changes in the brain

[1] K. F. Meyer, C. M. Haring and B. Howitt, SCIENCE, 74: 227, 1931; *Jour. Am. Vet. Med. Assn.*, 79 (n. s. 32): 376, 1931.

[2] B. Howitt, *Proc. Soc. Exp. Biol. and Med.*, 29: 118, 1931; K. F. Meyer, *Ann. Int. Med.*, 6: 645, 1932.

[3] All operations were performed under ether anesthesia.

[4] For a description of experimental vesicular stomatitis pathology, see H. R. Cox and P. K. Olitsky, *Proc. Soc. Exp. Biol. and Med.*, 30: 653 and 654, 1933.

and cord are apparently identical, the same type of intranuclear inclusion body is found in the neurones, and similar tissue lesions occur in the liver and kidney of the monkeys, guinea-pigs and mice which have succumbed to either experimental encephalomyelitis or vesicular stomatitis.

Pad Inoculation of Guinea-Pigs: Both viruses injected into the pads of guinea-pigs induce vesicular reactions varying in degree and transmissible indefinitely in series from pad to pad. As a rule, the serous exudate within the vesicles resulting from the virus of encephalomyelitis is blood-tinged, while that from the virus of vesicular stomatitis is clear. The microscopic changes in the affected pads are identical and the epithelial cells show the same type of intranuclear inclusion bodies.[5]

Only the pad tissue of the dermal surface is uniformly susceptible to both viruses, and after five or six serial pad passages of the encephalomyelitic virus, the inoculated animals fail to exhibit signs of nervous involvement; such animals, after recovery, are resistant to intracerebral inoculation of the encephalomyelitic virus. Corresponding immunity reactions occur with the vesicular stomatitis virus.

Inoculation of Mice: The white mouse is highly susceptible to both viruses, whether inoculated intracerebrally or instilled intranasally. Tissue cultures of the viruses in dilutions of 10^{-6}, mouse brain in dilutions of 10^{-7}, and Seitz filtrates of affected guinea-pig pad, are all capable of inducing fatal infections characterized by the same set of symptoms and microscopic changes in the nervous system, liver and kidney.

Immunological Reactions: The results of repeated tests indicate that cross-immunity reactions do not occur between encephalomyelitis and stomatitis viruses.

Other Properties: The two viruses have been cultivated in tissue cultures composed of chick embryo tissue and Tyrode's solution,[6] for over forty generations, without loss of infectivity for guinea-pigs and white mice. The filterability through Seitz disks of both incitants is of the same degree: they pass the filters in a concentration of 10^{-5}.

To summarize, the viruses of equine encephalomyelitis and vesicular stomatitis are similar in many but not all biological properties, and since the horse is the natural host for the two infectious agents, it is suggested that they may be generically related. However, inasmuch as cross-immunization does not occur, it follows that they are not identical. Just as there are at least three types of foot-and-mouth disease and two of vesicular stomatitis viruses, each immunologically distinct, the absence of cross-immunity does not exclude the possibility of a generic relationship.

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[5] For a description of experimental vesicular stomatitis dermatitis, see P. K. Olitsky and P. H. Long, *Proc. Soc. Exp. Biol. and Med.*, 25: 287, 1928; P. K. Olitsky, *Jour. Exp. Med.*, 45: 969, 1927.

[6] H. R. Cox, J. T. Syverton and P. K. Olitsky, *Proc. Soc. Exp. Biol. and Med.*, 30, 896, 1933.

A RESPIRATION COENZYME

MANY studies have been reported in recent years dealing with the stimulating effect of various factors on the growth of lower organisms. There are extremely few instances on record, however, where it has been shown that increased growth was due specifically to an increased rate of respiration, that is, to an increased rate of oxygen consumption per unit dry weight of organism.

A factor not only specific but essential for respiration has been found at this laboratory. Certain organisms fail to reproduce or to make appreciable growth in the absence of this factor because of inability to respire. Its addition to the medium in sufficient quantity causes the rate of respiration per unit weight of organism to assume the normal maximum value within an hour or less, whereas the initiation of normal growth does not take place until several hours later. If relatively small quantities of the respiration factor are added the rate of respiration then assumed will vary according to concentration. The specificity of the factor for respiration, as distinguished from growth, has also been demonstrated by studying the behavior of the organisms under conditions where growth is impossible, for example, in a nitrogen-free medium.

Many properties of the respiration factor have been determined, even though it has not yet been isolated in chemically pure form. It is easily obtained in a reasonably concentrated form by extracting commercial sucrose with absolute alcohol. As little as 5 parts per million dry weight of such an extract (still consisting mostly of sugar) is sufficient to give a respiration rate approximately half the maximum. The same concentration will also stimulate the growth rate to almost as marked an extent during a growth period of some 3 or 4 days. The factor is soluble in water and in absolute alcohol, but insoluble in the ordinary fat solvents. Spectroscopic analysis did not show the presence of any inorganic element. Furthermore, active extracts lose their biological effect when ashed. The factor is readily dialyzable and heat stable, that is, it may be autoclaved repeatedly at 15 pounds pressure without appreciable effect on its activity. Be-

cause of these last two properties, and the additional facts that it may be separated from living organisms, and that it has a direct effect on a specific chemical reaction (respiration), the factor is classifiable as a respiration coenzyme. For convenience it has been designated as coenzyme R, the R referring to respiration. Whether it is related to any of the active fractions in other organic extracts capable of stimulating growth or respiration, variously called bios, rhizopin, pnein, auximones, certain vitamins, Euler's activator, Z complex, etc., is still an open question. It is certainly not identical with bios, since its addition to a synthetic medium essentially free from bios resulted in a growth of yeast negligible compared with the heavy growth obtained where bios was present. Work now in progress on the purification of the coenzyme involves the determination of its more strictly chemical properties; its possible relation to the other active factors mentioned; the possibility of further fractionation; and whether it affects a fermentative step or a strictly oxidative step (involving oxygen gas) in the normal respiration of the organism.

The test organism used to the greatest extent in these studies was the red clover root nodule organism (*Rhizobium trifolii*). With this organism the rate of respiration increases from a small value in the presence of a trace of the factor to as high as 1,000 cmm O_2 per mg dry weight per hour ($Q_{O_2} = 1000$) at 31° C. in its presence. The determinations were made by means of the Warburg[1] apparatus. This value is somewhat higher than for most organisms. Carbon dioxide production is ordinarily affected to the same approximate extent as oxygen consumption, that is, the respiratory quotient remains practically constant. This holds both under aerobic conditions and under conditions of partial oxygen deficiency. Less extensive studies with a number of other species of legume nodule bacteria show that the factor is also essential for the alfalfa, pea and bean nodule bacteria, while the responses with soybean and cowpea bacteria were less striking, due probably to the slower rate of growth of these organisms. It is not, however, specific for legume bacteria, since some of the other bacterial species tested gave similar responses. Reducing substances, such as cystine, thio-glycollic acid and glutathione, do not in any degree act as substitutes for coenzyme R. The same is also true of active iron preparations such as synthetic humate iron, provided that they are free from the respiration factor. Such active iron, which so markedly stimulates the rate of growth (not of respiration) of Azotobacter[2] growing in a synthetic medium, has a less marked effect on Rhizobia and then only in case the coenzyme is also added. This is true because these organisms need very much less iron than does Azotobacter. Natural humates, however, contain both the coenzyme and available iron, hence they greatly increase the growth of both Rhizobia and Azotobacter. In legume symbiosis the host very probably furnishes the bacteria living on the roots, with an adequate supply of the respiration factor just as it is known to furnish carbohydrates and mineral matter.

Special reference should be made to the behavior of Azotobacter. These organisms make a normal growth on a medium essentially free from all traces of the respiration factor. This is interesting, in view of the fact that Azotobacter has substantially the highest rate of respiration ($Q_{O_2} = 5000$) possessed by any organism. A study made of *Azotobacter vinelandii* showed that the respiration coenzyme is synthesized by this organism and given off into the medium in considerable quantities. Older cultures (5 days) contain considerably more of it per unit dry weight of the organism than do younger cultures.

The source of the material usually used in our chemical work has been commercial cane sugar, but undoubtedly yeast, cane molasses, natural humic acid, crude egg albumen and many plant extracts would be more concentrated but more impure sources. The indications are that the coenzyme is widely distributed throughout the plant and animal kingdoms.

It may be of interest to those workers engaged in the study of legume nodule bacteria to state that these organisms ordinarily make a growth on a sugar-mineral medium, containing a suitable source of nitrogen and the respiration factor, that is substantially as good as in the presence of yeast extract. The most suitable form of nitrogen, whether nitrate, ammonia, asparagin, urea or some other, will vary with the bacterial strain. These facts show that, aside from furnishing readily available nitrogen, the chief role of the yeast water in the case of the nodule bacteria is to supply a source of the essential respiration factor.

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[1] *Jour. Phys. Chem.*, 34: 1183, 1930, fig. 4.
[2] SCIENCE, 74: 522–524, 1931.

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